



## A Deep Learning Approach for Early Autism Detection

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### Abstract

*Among the most widely studies neurodevelopmental condition characterized by major differences in social communication, interpersonal interaction, and behavioral patterns, with considerable variability across individuals. Early detection is critical for intervention and long-term developmental outcomes. However, conventional diagnostic procedures can be time consuming, subjective, and dependent on specialized professionals. In this work, we present a system based on deep learning for early detection of ASD for both facial images and video data and using a convolutional neural network to extract features from static images and video analysis to capture dynamic facial patterns that may reflect the behavior related to ASD. The system is built as a user friendly Streamlit web application that accepts image uploads or video and gives prediction results and downloadable reports. This system is particularly accessible and easy to use. This combination of static and dynamic facial analysis can capture high range of behavioral indicators with less human bias, which is well suited for preliminary screening in resource limited settings. There is an integrated chatbot that gives information about autism that raises awareness and engagement among the users. Artificial intelligence has a role to play in early screening and awareness for autism. This paper presents about detecting autism disorders using deep learning.*

**Keywords:** Autism Spectrum Disorder (ASD), Deep Learning, Convolutional Neural Networks (CNN), Facial Image Analysis, Video-Based Behavioral Analysis, Early Autism Detection, Streamlit Web Application.

### 1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects communication, social interaction, and perception of the world. The early prediction of autism is tough, but traditional method involves consulting the autism specialist and time consumes a lot and sometimes not always readily available. Recent progress in deep learning has enabled new features for healthcare application, where we would upload image and video that would analyses the behavioral and facial expressions-based patterns. This project aims to implement a deep learning-based system for early autism.

#### 1.1.Problem Statement

Current autism diagnosis mainly depends on specialist observation and interviews. This process can take a long time, subjective, and is not easily available to all families. Many existing automated methods depend only on static images or

questionnaires, which often focus on important behavior signals. There is a clear need for an automated screening system that examines both facial images and video to deliver faster and more objective preliminary results. The system can be useful to healthcare professionals to identify individuals who and all need further clinical evaluation, without replacing the formal treatment. Easily accessible tools are also important so that everyone including parents, caretakers can able to access and understand the outcomes easily.

#### 1.2.Proposed Solution and Key Contributions

This paper describes a straightforward and good supporting system for early Autism Spectrum Disorder (ASD) screening. It is used to combine the deep learning, explainable AI, and very user-friendly web interface. The major contributions of the project work are given below:

##### 1.2.1. CNN-Based ASD Detection

A convolutional neural network is built to automatically identify the face and behavioral pattern that is linked to ASD. Using the transfer learning with the previous trained models like ResNet50 and Mobile Net improves accuracy and reliability over various datasets.

### **1.2.2. Explainable AI for Transparency**

The tools like Grad-Cam and SHAP were added to make the results very easier to understand. These help to show which parts of the image helped to make a prediction, helping parents and doctors to observe the reason for the decision that system made.

### **1.2.3. Easy to Use Web App**

The system runs on a streamlit web app where users can upload images and get instant predictions. It also provides downloadable reports that can be shared with healthcare professionals in a pdf viewable format.[14]

### **1.2.4. Lightweight and Portable**

For running in the mobile or devices, we converted model in the formats of TensorFlow Lite and ONNX so that it could run fast with limited resources. This helps the tool practical for real time screening that works outside of hospitals or labs.

## **1.3.Related Works**

### **1.3.1. Behavioral and Questionnaire – Based Machine Learning**

The earliest efforts to detect autism leaned heavily on clinical observation and structured questionnaires rather than heavy approaches. The notable step forward came with Kosmicki et al.(2015) [1], whose work says that even a small collection of behavioral features that fed into the machine learning models that could support ASD screening. The finding that pointed towards more scalable, efficient pipelines that would approach was not without its limitations and relied on the self-reported data introduced the familiar risks of response bias and that have raised questions about the general across demographically different populations. Despite these conditions, the study have proven that the influential in building a conceptual blue print for data driven screening. Around the same period, Berumen et al, (1999) [2] pursued the complementary line of inquiry that focus

on validating the Autism Screening Questionnaire as a reliable instrument for the clinical observations work that reinforced the growing for the common view of the people for the standardized tools, while imperfect that could serve as meaningful entry points into the diagnostic process.[8]

### **1.3.2. Deep Learning with facial and Image Data**

Most recent research have used the CNN to observe facial images for autism detection. Pre trained models such as VGG, Inception, and MobileNet have obtained its high accuracy when it is combined with the good preprocessing and explainable AI techniques. These approaches focus on the image-based screening system that will be both effective and easier to use.[3]

### **1.3.3. Multimodal and Neuroimaging Techniques**

Beyond facial analysis, researchers found the brain imaging methods such as MRI, FMRI, EEG, and eye tracking signals. Deep learning model can easily observe the structural and functional brain patterns that is linked to the ASD [4]. By joining the different types of behavioral and physiological data. These systems have improved the prediction accuracy and capture the developmental traits.[5]

### **1.3.4. Explainable AI in ASD Diagnostics**

Day by day, automated detection tools becoming advancing and transparency is very important. Techniques like Grad-CAM and SHAP that help to visualize that which features influenced the model's decision. This would help to make the results easier to trust and acceptable in clinical settings and helps the doctor to find the validate observations.

### **1.3.5. Text and Behavioral Analysis for ASD Detection**

Researchers have studied language and communication patterns using the natural language processing (NLP).[8] By observing the told stories, social media posts, or medical transcripts, machine learning models could identify the linguistic markers of ASD. Architectures like LSTM, Bi-LSTM, BERT and BERTweet have used to varies between individuals with and without ASD, that is reaching

the accuracies around 88%. This shows the potential of the text based on the screening , especially when it is applied to the social media or some other health records, where subtle communications variations could be captured at scale.[6][7]

## 2. System Overview

### 2.1.System Architecture And Approach

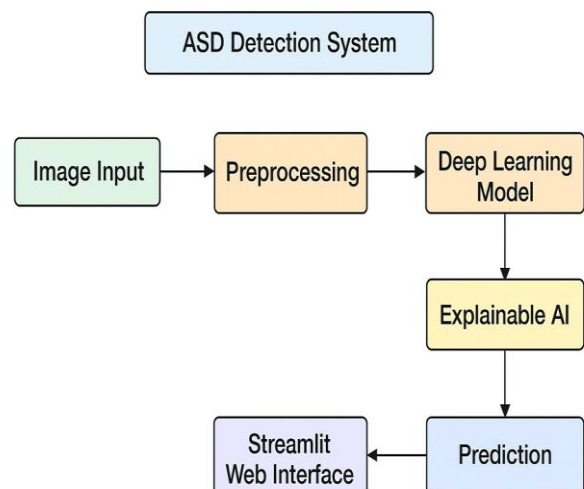
We have designed our autism screening platform to be the clear one and very easy to use. The system is built with the separate parts like image processing, prediction, explanation, and the user interacting the work together but that could be updated individually by without affecting the whole system setup. The convolutional Neural Network (CNN) that is in the center of the tool and it uses the transfer learning to study facial and behavioral images and identify the patterns that is linked t the ASD. To make the results easier to trust, we have added the explainable AI methods like Grad-CAD and SHAP that would show the areas of the image that can be influenced the prediction. The platform is running on the streamlit app, where the users can able to upload their images and they would get the results immediately and also download the detailed reports in the PDF format.[14] The model have been trained to optimize for running smooth even with the limited resources devices. Overall, the design is very simple, users can use easily, scalable, and helping the families, doctors, and caregivers to observe the early autism screening.[9]. As Shown In Table 1.

**Table 1 ASD Detection Model Performance**

| Metric    | Value  | Description                     |
|-----------|--------|---------------------------------|
| Accuracy  | 84.92% | Overall prediction correctness  |
| Loss      | 0.3681 | Test dataset Loss               |
| F1-Score  | 0.94   | Balance of precision and recall |
| Precision | High   | Correct ASD predictions         |
| Recall    | High   | Detection of actual ASD cases   |

### 2.2.Overall System Architecture

Autism detection system has been built with the clear, layered design that could make the use more flexible and easier to maintain. Each part of the system like image processing, prediction, explanation, and showing that the results have their winning role but it works together as a one. In this way, we can able to improve or update a single part of the system without affecting the others. The CNN model is the main engine of the tool and it uses the transfer learning to study the facial and behavioral images and that would find the patterns that is linked to the ASD. The explainable AI methods Like Grad-CAM and SHAP have been added to understand the results easier and that would show how the model was reached to its decision. As Shown in Figure 1.



**Figure 1 Understanding The ASD Detection Workflow**

### 2.3.Input And Data Acquisition Layer

In the first phase, users can able to upload their facial or behavioral images into the streamlit web app. The interface was designed for the easy use , so that caretakers, doctors, or researchers can access it without any need of technical skills and special device. It supports all the image formats even common image formats and it helps to give the necessary information to make the process smooth. Once image is uploaded, it is sent safely into the

backend for processing. Then the system checks for the quality and formats to make sure that the input is reliable before moving it to the forward, because of the straightforward design, hence this app can be used in clinics, schools and even in home especially in the areas where the network and professional resources are very less.

#### 2.4. Module for Preprocessing Data

Before the observations, the uploaded image sent into the preprocessing step so that making sure that they are clear and consistent. Each image is resized to 224 x 224 pixels, and the pixels values are get adjusted to the same range. Basic checks were done to make the image clear and to avoid the blurry or unsuitable images and making the predictions more accurate.

#### 2.5. Deep Learning Model Layer

CNN model is the main part of the system that helps to learn visual patterns to form the images. It starts by capturing simple shapes like edges and textures, then moves on to more complex features. We are using the transfer learning because reducing the training time and to improve accuracy. We use transfer learning with the pre trained models such as ResNet50 and Mobile Net.

#### 2.6. Explainable AI (XAI) Module

To make the results easier to understand, the system uses explainable AI methods. Grad-Cam created heatmaps to highlight important areas in the image, while SHAP shows which features influences the prediction. These explanations help caregivers and clinicians trust the results of this interface more effectively

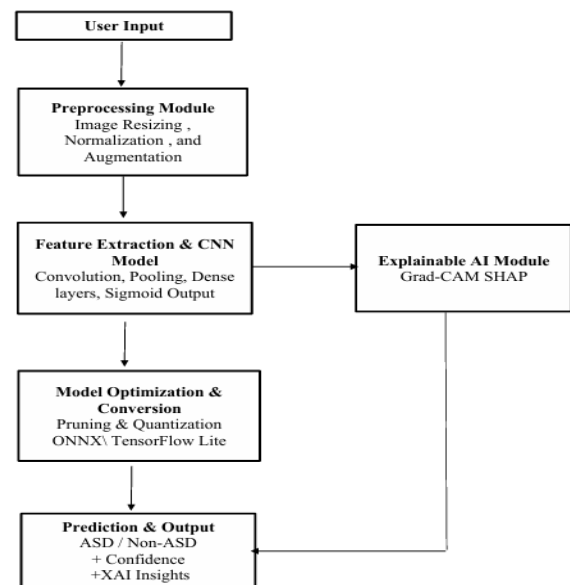
#### 2.7. System Design

The workflow is straightforward:

- The user uploads an image.
- The image is resized and normalized during preprocessing.
- The processed image is sent to the CNN model, which extracts key features.
- Dense layers classify the image and produce the final prediction.

Grad- CAM and SHAP show the features that influence the model's decision. The model is designed for efficient deployment. The system

provides predictions along with confidence scores and clear explanations. As Shown in Figure 2.



**Figure 2 System Design of ASD Detection Model**

#### 2.8. Implementation Details

The system uses a customized CNN to analyze images that are 224 x 224 pixels. In early layers, the model detects simple patterns like edges and textures. As it goes deeper, it learns more difficult features. A sigmoid output layer gives a binary prediction (ASD or Non-ASD) along with confidence scores. Using transfer learning with models like ResNet50 or Mobile Net accelerates training on a dataset of 4,000 images, achieving an accuracy of 84.92%.

##### 2.8.1. Data Preparation Steps

Images are resized, normalized to 0-1 range, and augmented with rotations, flips, zoom, and brightness adjustments to improve generalization. Here labels were converted into the binary format and marked ASD as 1 and Non-Asd as 0 to keep the dataset more clean and reliable. It removes the blurry and duplicate images so that it can use high quality data for training and prediction.

##### 2.8.2. Training Process

The model was trained using the binary cross entropy loss and Adam optimizer that would help to learn



effectively. We are using metrics like accuracy, precision, recall, F1 score and ROC-AUC for measuring the performance. The confusion matrix helps to show that system can separate ASD from Non-ASD.

### 2.8.3. System Integration

After the image is uploaded, the system can quickly predict the risk of the ASD and it would generate the visual explanations with the Grad-CAM heatmaps. We are adding speech and video analysis in the future. The app is simple and user friendly so that easy to use and giving result within a minute. The main special thing is it can be run on both online and offline. [13]. Adaptive thresholds will help to adjust dynamically based on the image quality or user location, further personalizing the screening process. [15]

### 2.8.4. Hardware Components

The model has been trained using the GPU based computer for faster processing. Once it is trained, it can make the predictions easy and smooth on light devices such as mobile phones or edge systems, making this practical in various environments. As Shown in Table 1

**Table 2 Hardware components**

| Component    | Specifications                                 | Modular/ Upgradeable                        |
|--------------|------------------------------------------------|---------------------------------------------|
| Training GPU | NVIDIA (CUDA- e.g., Tesla K80/A100 equivalent) | Replaceable for faster epochs. [11] [12]    |
| CPU/RAM      | 2.7GHz+, 256GB RAM                             | Scalable; add for larger datasets [10]relab |
| Deployment   | Mobile CPUs                                    | Independent; no GPU needed                  |
| Storage      | SSD 4000 and more images/models                | Expandable for new data/models              |

### 2.8.5. E. Cloud/Offline Services

As Shown in Table 3.

**Table 3 Cloud/Offline Services**

| Service         | Role                              | Modular/ Upgradeable                                             |
|-----------------|-----------------------------------|------------------------------------------------------------------|
| Offline Core    | TFLite (quantized/pruned models)  | Self-contained; upgrade model files alone.                       |
| Optional Cloud  | AWS/GCP for hyperparameter tuning | Modules can be switched on or off independently [12]             |
| Version Control | GitHub                            | Each one can be updated without affecting the rest of the system |

## 3. Results and Discussion

This app was tested using the 4000 labeled image contains both ASD and Non-Asd images in real world settings with the various lightings and backgrounds. In the new test data, the model has reached the accuracy of 84.92 % and a loss of 0.3681, showing that the fast and good performance

### 3.1. Results

- **Accuracy (84.92%):** The model correctly classified more than 8 out of 10 images, making it a strong option for early screening, As Shown in Figure 3.

Evaluating the performance of the model with test dataset

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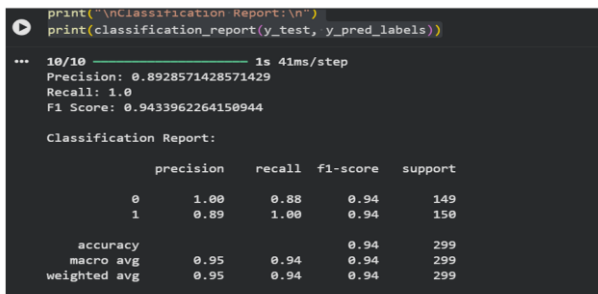
cnn.evaluate(X_test, y_test)
10/10 2s 80ms/step - accuracy: 0.8492 - loss: 0.3681
[0.2581683397293891, 0.9038100107192993]

```

**Figure 3 Performance Evaluation**

- **Precision:** High precision reduces the false alarms and it gives the most ASD likely predictions.
- **Recall:** Focused on capturing as many true ASD cases so that it would help to reduce the missed captures.

- **F-Score (~0.94):** This can help to balance the precision and recall, showing consistent in the overall performance.
- **Loss (0.3681):** The low loss value shows that the good generalization without overfitting of the system.
- **Confusion Matrix:** This shows a clear separation among the classes. Most of the predictions falling correctly with the diagonal of the confusion matrix. As Shown in Figure 4.



**Figure 4 Precision, Recall, F1 Score**

Overall, the results show that the system works reliably as an early screening tool, but it does not replace professional diagnosis.

### 3.2. Discussions

The system is tested with a dataset contains the 4000 images with label and it also contains the both ASD and Non-Asd images. These images were taken from the verifies[13] public databases and it includes the different age , genders, and the backgrounds to reduce the bias. To improve the good evaluation, we have slitted into 70% for the training, 15 % for testing and 15 % for the validation. All the images resized into the 224 x 224 pixels and it got normalized before the training. The model training was done using the TensorFlow[14]/ Kera's with the GPU acceleration. The hyperparameters tuned for this system and calculated all the metrices. The final model was optimized and it is converted into the TensorFlow Lite format for the deployment and works even in low resource network and devices. Visual heatmaps would help to highlight the facial parts that would help to make the decision. This can help to make the

output more easier for the parents ad clinicians[15].

### Conclusion

For now, we have developed the user-friendly ASD detection system using web interface model streamlity. This system allows the users to upload their images and fastly observe the results that the signs relatable to autism or not. The main goal is to build the deep learning model and to create the practical tool that would supports early awareness in the simple way. We have developed chatbot to ask some questions and also added feature to download their medical report as a PDF format and also they would find the nearby doctors using the google maps. Overall, we have built a model that includes the image upload, generate report , basic chatbot and doctor recommendations so that it would help to find early autism awareness in a good way.

### Future Scope

In the next phase , we would be trying to add video and voice and improved version of chatbot for the proper prediction and more engaging with the users. These improvements will help us to make the system more reliable, accessible, and user centered, supporting early detection and awareness of ASD in a real-world setting.

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